Studies of the Origins of the Kuroshio and Mindanao Currents with EM-APEX Floats and HPIES

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LONG-TERM GOALS

Improving observations and understanding of major oceanographic features and phenomena. We emphasize motionally induced electric fields for measuring ocean velocities. Specific goals for OKMC include:

- Observe Bt and Bc velocity around Ren-Chieh Lien's upper ocean ADCP moorings with HEF (Horizontal E-Field) and PIES (Pressure and Inverted Echo Sounder) merged into 5 HPIES under the Kuroshio north of Luzon
- Observe velocity and density structure of NEC with 10 EM-APEX floats deployed along 135°E, 10°-18°N
- Document the entrainment of NEC upper-ocean transport into the formation of the Kuroshio
- Combine results with complementary observations with gliders, drifters, ship observations, Taiwanese moorings and numerical models

APPROACH

The motion of seawater through the vertical component of the Earth's magnetic field produces electric fields and electric currents. The horizontal electric field (HEF) is proportional to the vertically averaged ocean velocity. A novel approach is to combine HEF sensor with an Inverted Echo Sounder (IES) and bottom pressure sensors (P). A spatial array of PIES has been used to determine the baroclinic or depth variable ocean velocity. HPIES is the combination, which is intended to observe the total velocity field from the sea floor for long duration.

An array of HPIESs complements the ADCP moorings in the Kuroshio near the NE tip of Luzon, the Philippines. The ADCP units will profile the upper 600 m or so of the water column. Thus, the HPIES determine the transport below the depth interval observed by the upward looking ADCP. Three complete HPIES exist from the original NSF development support. Two new HPIES are being built using existing PIES and new HEF units. The HPIES instrument is shown in the figure below.

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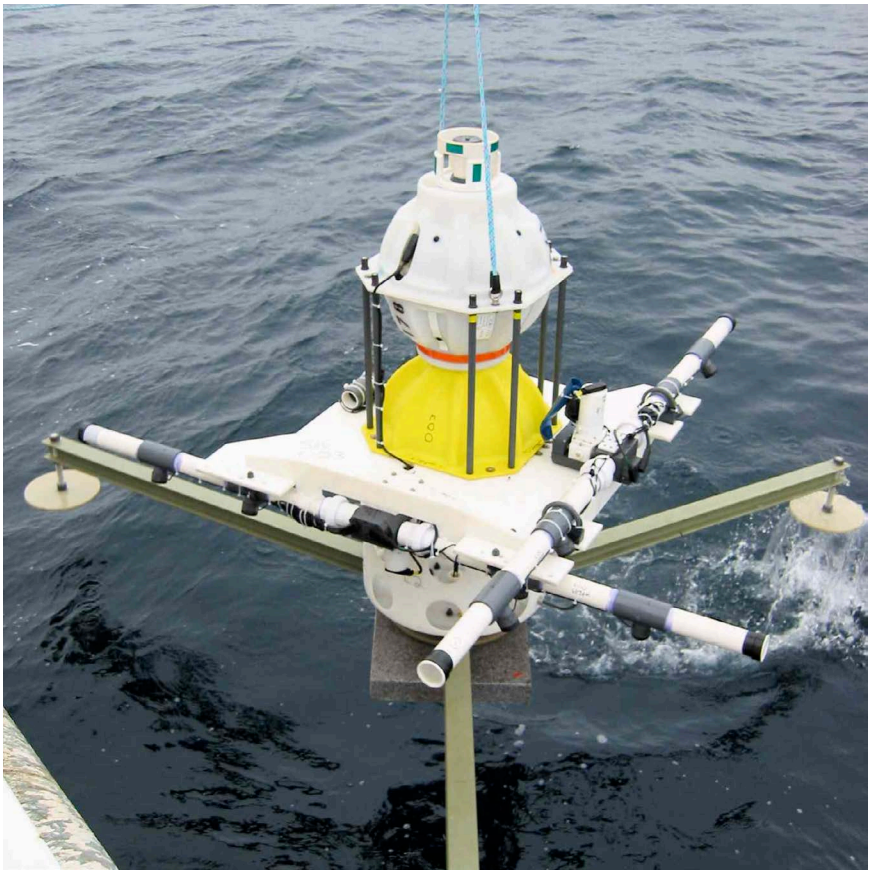

Fig. 1: HPIES being deployed. The instrument on top, in the while plactic hardhat, is the URI CPIES. The acoustic transducer for the IES (Inverted Echo Sounder) is on the top. The instrument in the lower, yellow hardhat, is the APL/UW Horizontal Electric Field (HEF) unit. The crossed white PVC pipes are the orthogonal axes over which the ocean electric field is measured. HEF, pressure and IES observations are available over acoutic transmission and are stored aboard for downloading on HPIES recovery

Five HPIES will be deployed around two upper ocean ADCP moorings by Ren-Chieh Lien. The ADCP is to be moored at 600-m level and upward looking. The HPIES will provide the depth-averaged velocity. Thus, the combination provides both upper-ocean Kuroshio transport and total-water transport. It is likely that the moorings and the HPIES will be installed NE of Luzon Is., probably in the Balintang Channel.

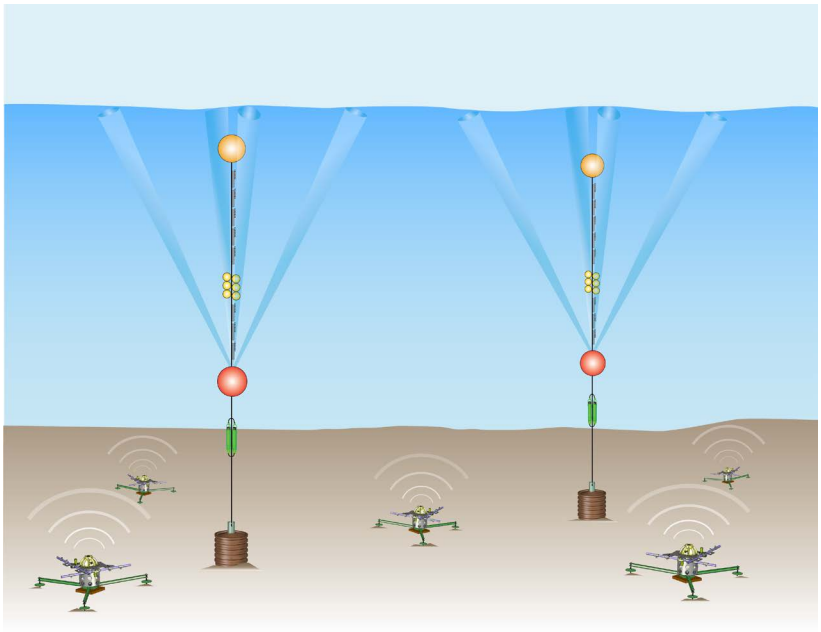

Fig. 2: Depiction of the HPIES installed around RC Lien's current meter moorings. Five HPIES can provide 3 HPIES every 120° around 2 moorings

In addition to the fixed HPIES near the moorings, we have submitted a DURIP proposal for 10 EM-APEX floats to be deployed in the NEC and surrounding flows that generally move toward the Philippines, where the flow bifurcates into the northward flowing Kuroshio Current or the southward flowing Mindanao Current.

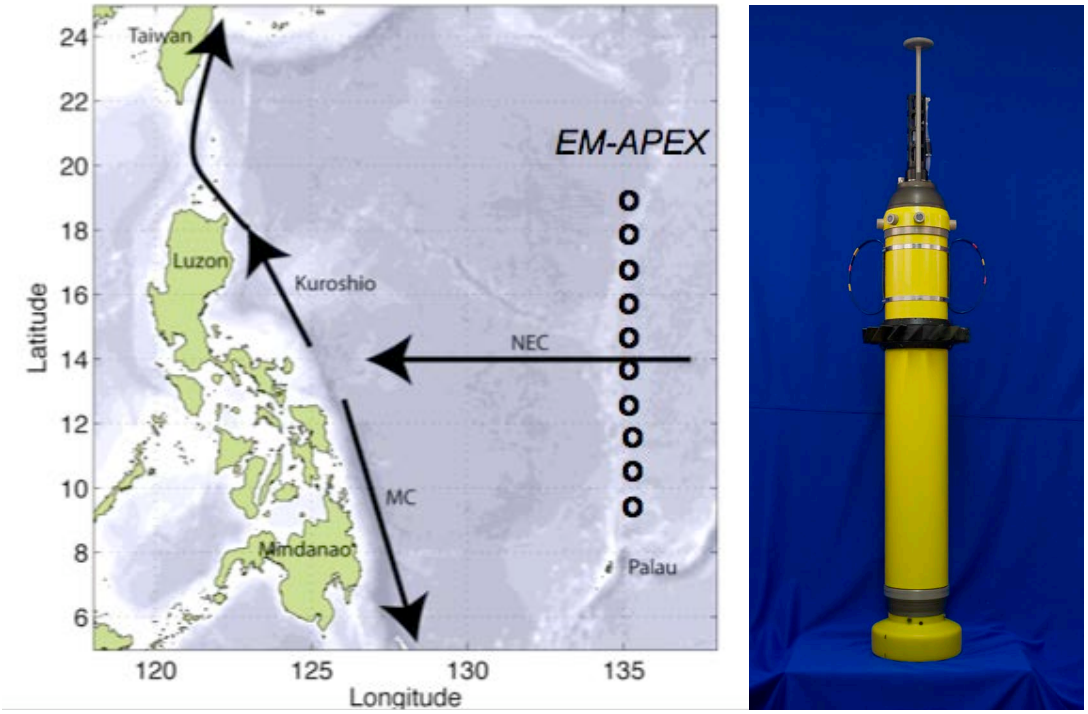

Fig. 3: Planned EM-APEX float deployments upstream of the region where the NEC waters form the Kuroshio or the Mindanao Current (MC). The Webb Research Corp. EM-APEX float is shown. The upper end cap has the Iridium/GPS antenna and SBE-41 CTD. Just below the end cap is the electrode collar. The black band the fan blades that cause the float to rotate as it moves vertically through the surrounding water. The lower end houses the oil and air bladders that changes the float buoyancy to drive the float up or down in the water column and higher out of the water on the surface.

WORK COMPLETED

Dr. Barry Ma presented our updated plans at the OKMC meeting in Taipei in November 2010. A DURIP proposal has been submitted for the purchase of the 10 EM-APEX floats.

The design of the instrument is being changed to reduce the volume of fluid surrounding the electronics and other components. The present design had unnecessary large volumes of fluid that changed volume greatly with pressure and temperature. The compensation mechanism was barely able to accommodate the volume changes.

Five HPIES are now being prepared. Two will be all new instruments. Because the bottom currents are expected to be strong, we are designing a new concrete base for the HPIES. Preliminary tasks have been to locate and purchase components that are no longer manufactured. There are several key electronic components that had to be located from specialty distributors.

The two new HEF units need to be made. There are expected orders for other projects, such as for the NSF's OOI Regional Scale Nodes project. Modifications to the design may be needed to reduce reproduction costs.

RELATED PROJECTS

Study of Kuroshio Intrusion and Transport using Moorings, HPIES and EM-APEX Floats (N00014-08-1-0558) as a part of QPE DRI: The primary objectives of this observational program are 1) to quantify and to understand the dynamics of the Kuroshio intrusion and its migration into the southern East China Sea (SECS), 2) to identify the generation mechanisms of the cold dome often found on the SECS, 3) to quantify the internal tidal energy flux and budgets on the SECS and study the effects of the Kuroshio front on the internal tidal energy flux, 4) to quantify NLIWs and provide statistical properties of NLIWs on the SECS , and 5) to provide our results to acoustic investigators to assess the uncertainty in the acoustic prediction. Results of this DRI program will help understand oceanic physical processes on the southern East China Sea, e.g., the cold dome. Typhoons may modulate the Kuroshio, the Kuroshio intrusion, and other oceanic processes and result in cold pools on the continental shelf of the SECS.

Process Study of Oceanic Responses to Typhoons using Arrays of EM-APEX Floats and Moorings (N00014-08-1-0560) as a part of the ITOP DRI. Fourteen EM-APEX floats were air-deployed into two W. Pacific typhoons. *T. Fanapi* was a category 1 tropical cyclone. Seven floats were deployed about a day in front of *Fanapi* in mid-September 2010. Similarly, 7 floats were deployed in front of Super Typhoon Megi in mid-October. All floats survived the deployment and reported profiles. We are studying the characteristics and dynamics of the oceanic response to and recovery from tropical cyclones in the western Pacific Ocean

*Quantify Lateral Dispersion and Turbulent Mixing by Spatial Array of χ-EM-APEX Floats (*N00014-09-1-0193) as part of the LatMix DRI. A suite of twenty-one EM-APEX floats, 10 with Chi turbulence sensors, was used in three experiments SE of Cape Hatteras, NC in June 2011. This was the first time a number of EM-APEX has been choreographed to profile simultaneously. For most of the time, the RMS differences on arrival at the surface as less than 1 minute. Only a single float was lost during the experiment, a result that partly was achieved by the development and use of a situation awareness system developed at APL for this experiment. Assets in the water were displayed on a dedicated screen on the bridge of each of the three research vessels. More than 8,000 CTD and velocity profiles were obtained in the three experiments. The data are being processed for distribution by 1 January 2012.

PUBLICATIONS (wholly or in part supported by this grant)

None

HONORS/AWARDS/PRIZES

None